1	$12^2 = 2^4 \times 3^2$ **or** $2 \times 12^2 = 2^5 \times 3^2$ oe **or** $\frac{2\times12^2}{3^2}(=32) = 2^5$		5	M1	
	$18^{4n} = (2 \times 3^2)^{4n}$ **or** $2^{4n} \times 3^{2\times4n}$			M1	
	$3n^2 - 14n - 5\ (=0)$			A1	
	e.g. $(3n + 1)(n - 5)(=0)$ $n = \frac{14 \pm \sqrt{(-14)^2 - (4\times3\times-5)}}{2\times3}$			M1	for solving their 3 term quadratic equation using any correct method - if factorising, allow brackets which expanded give 2 out of 3 terms correct (if using formula or completing the square allow one sign error and some simplification – allow as far as e.g. $\frac{14 \pm \sqrt{196+60}}{6}$ oe)
		$-\frac{1}{3}$, 5		A1	Allow −0.33 or better for $-\frac{1}{3}$
					Total 5 marks

2	(a)		0	1	B1	condone 150^0
	(b)		−2	1	B1	condone 3^{-2}
						Total 2 marks

3	(a)		5^{19}	1	B1	
	(b)			2	M1	A factor tree / division ladder of 3 or more factors (≠1), multiplying to 800, which must include 2 and 5. Condone 1 error when product ≠ 800
			$2\times2\times2\times2\times2\times5\times5$		A1	dep on M1 oe eg $2^5 \times 5^2$
						Total 3 marks

4	(c)		1	1	B1

5	(b)	E.g. $\left(\frac{3a^4}{t^5}\right)^{-2}$ or $\left(\frac{t^{15}}{27a^{12}}\right)^{\frac{2}{3}}$ or $\left(\frac{729a^{24}}{t^{30}}\right)^{-\frac{1}{3}}$		3	M1 for **one** of cube rooting **or** inverting **or** squaring **or** $\frac{ka^{-8}}{t^{-10}}$ where k is an integer ≠ 0
		E.g. $\left(\frac{9a^8}{t^{10}}\right)^{-1}$ or $\frac{3^{-2}a^{-8}}{t^{-10}}$ or $\frac{\frac{1}{9}a^{-8}}{t^{-10}}$ or $\left(\frac{t^5}{3a^4}\right)^2$ or $\left(\frac{t^{30}}{729a^{24}}\right)^{\frac{1}{3}}$ or $\frac{a^{-8}}{9t^{-10}}$			M1 for **two** of cube rooting **or** inverting **or** squaring **or** $\frac{t^{10}}{ka^8}$ where k is an integer ≠ 0
			$\frac{t^{10}}{9a^8}$		A1 Allow $\frac{t^{10}a^{-8}}{9}$ or $\frac{1}{9}t^{10}a^{-8}$

6	(a)		x^7	1	B1	
	(b)	eg $7^8 \times 7^4 = 7^{12}$ or $7^8 \div 7^3 = 7^5$ or $7^5 \times 7^4$ or $7^4 \div 7^3 = 7$ or $7^8 \times 7$ or $7^{'12'} \div 7^3 = 7^{'12'-3}$		2	M1	for one correct step – must be written as a power of 7
			7^9		A1	for 7^9
						Total 3 marks

7	b		1	1	B1

8	(a)		1	1	B1

9		(definition of part: there are 3 parts: one part is the number, one part the letter t and one part the letter w Definition of terms: there are 6 terms: 2 number terms, 2 terms in t and 2 terms in w)		3	M1 indep	Fully correct cancellation of any two parts of their fraction at any stage of working
					M1 indep	correctly apply the negative power to the whole of their bracket (all parts or all terms) **or** correctly square all parts or terms of their bracket **or** correctly apply the negative power AND square of at least two parts (maybe 4 terms) of their bracket
			$4t^4w^2$		A1	Allow $(2t^2w)^2$ after the correct answer
		ALTERNATIVE				
				3	M2	2 correct terms (M1 for 1 correct term)
			$4t^4w^2$		A1	Allow $(2t^2w)^2$ after the correct answer
						Total 3 marks

10	(b)		$3^{11}\times5^7\times7^5$	2	B2 fully correct answer (allow $x = 11$, $y = 7$, $z = 5$) (B1 for an answer in the form $3^p\times5^q\times7^r$ where one or two of p, q or r are correct)

11	(b)	$\left(\frac{8xy^2}{2x^5}\right)^2$ **or** $\left(\frac{x^4}{4y^2}\right)^{-2}$ **or** $\left(\frac{4x^{10}}{64x^2y^4}\right)^{-1}$		3	M1	for one of reciprocating or simplifying or squaring
		$\left(\frac{4y^2}{x^4}\right)^2$ **or** $\left(\frac{x^8}{16y^4}\right)^{-1}$ **or** $\frac{64x^2y^4}{4x^{10}}$ **or** $\frac{\frac{1}{4}x^{-10}}{\frac{1}{64}x^{-2}y^{-4}}$			M1	for two of reciprocating or simplifying or squaring
			$\frac{16y^4}{x^8}$		A1	accept $16y^4x^{-8}$ or $\frac{16}{y^{-4}x^8}$ or $\frac{16x^{-8}}{y^{-4}}$ oe
		ALTERNATIVE				
				3	M2	for 2 correct terms (M1 for 1 correct term)
			$\frac{16y^4}{x^8}$		A1	accept $16y^4x^{-8}$ or $\frac{16}{y^{-4}x^8}$ or $\frac{16x^{-8}}{y^{-4}}$ oe

12	(b)		1	1	B1	
	(c)		$\frac{y^2}{2x}$	2	B2	for $\frac{y^2}{2x}$ oe eg $\frac{0.5y^2}{x}$, $0.5y^2x^{-1}$, $\frac{y^2x^{-1}}{2}$, $\frac{1}{2xy^{-2}}$ oe If not B2, award B1 for 2 of number, x, y correct eg $\frac{ky^2}{x}$ where $k \neq \frac{1}{2}$ **or** $\frac{y^2}{2x^m}$ where $m \neq 1$ **or** $0.5y^2$ **or** $\frac{y^p}{2x}$ where $p \neq 2$) **oe** [one term can be missing with 2 correct for B1]

13	(a)		8	1	B1
	(b)		11	1	B1 accept x^{11}
	(c)		$8k^6m^{12}$	2	B2 for all correct B1 for two correct from 8 or k^6 or m^{12}
					Total 4 marks

14	eg $\frac{2\times3\times3\times(3^{\frac{3}{2}})^{4n+6}}{2\times3\times3^{2(2n+8)}}$ or $\frac{3\times3^{\frac{3}{2}(4n+6)}}{3^{2(2n+8)}}$ $\sqrt{27}$ to be changed to a power of 3 and not $3\sqrt{3}$ unless recovered		3	M1	For **2** of: • writing 18 as 2×3^2 oe **and** 6 as 2×3 **OR** cancelling 6 & 18 fully • writing $\sqrt{27}$ as $3^{\frac{3}{2}}$ or $3\times3^{\frac{1}{2}}$ **OR** $\left(\sqrt{27}\right)^{4n+6}$ as $\left(3^3\right)^{2n+3}$ or 3^{6n+9} • writing 9 as 3^2 **OR** 9^{2n+8} as $3^{2(2n+8)}$ or 3^{4n+16}
	eg $\frac{3\times3^{6n+9}}{3^{4n+16}}$ or $\frac{3^{6n+10}}{3^{4n+16}}$ or $\frac{3\times3^{1.5(4n+6)}}{3^{2(2n+8)}}$ or $\frac{3^2\times3^{6n+9}}{3\times3^{4n+16}}$ or $\frac{3^{6n+11}}{3^{4n+17}}$ oe or eg $3^{6n+11}=3^x\times3^{4n+17}$ oe			M1	For a correct expression or equation using only powers of 3 (powers of 3 but not necessarily a single power)
		$2n-6$		A1	oe eg $2(n-3)$ dep on M1
					Total 3 marks

15	(a)		x^9	1	B1 cao
	(b)		$64y^6$	2	B2 for $64y^6$ (B1 for ky^6 where $k\neq64$ **or** $64y^m$ where $m\neq6$)
	(c)	$(n\pm3)(n\pm4)$		2	M1 for $(n\pm3)(n\pm4)$ or $(n+a)(n+b)$ where $ab=12$ or $a+b=-7$ Condone use of a different letter to n
			$(n-3)(n-4)$		A1
					Total 5 marks

16	(a)		1	1	B1
	(b)		6	1	B1
	(c)	$206+m-214=-3$ oe or $\frac{7^{-3}\times7^{214}}{7^{206}}$ or $\frac{7^{211}}{7^{206}}$ oe		2	M1 allow $7^{206+m-214}=7^{-3}$ oe (must be in the form $7^x=7^y$ where x and y are correct expressions)
			5		A1 accept 7^5
					Total 4 marks

17	(a)		a^{11}	1	B1
	(b)		w^{12}	1	B1
	(c)		$64x^{10}y^6$	2	B2 if not B2 then award B1 for 2 correct parts as part of a product eg $kx^{10}y^6$ where $k\neq64$ **or** $64x^ky^6$ where $k\neq10$ **or** $64x^{10}y^k$ where $k\neq6$
	(d)	$c+8v=t^3$		2	M1
			$t=\sqrt[3]{c+8v}$		A1 oe SCB1 for an answer of $t=\frac{c+8v}{3}$ oe
					Total 6 marks

18 (b)	$\left(\frac{2w^2}{y^5}\right)^{-3}$ or $\left(\frac{y^{20}}{16w^8}\right)^{\frac{3}{4}}$ or $\left(\frac{4096w^{24}}{y^{60}}\right)^{-\frac{1}{4}}$		3	M1	for one of fourth rooting or reciprocating or cubing
	$\left(\frac{8w^6}{y^{15}}\right)^{-1}$ or $\frac{2^{-3}w^{-6}}{y^{-15}}$ or $\frac{\frac{1}{8}w^{-6}}{y^{-15}}$ or $\left(\frac{y^5}{2w^2}\right)^3$ or $\left(\frac{y^{60}}{4096w^{24}}\right)^{\frac{1}{4}}$ or $\frac{0.125y^{15}}{w^6}$ or $\frac{0.125w^{-6}}{y^{-15}}$ or $\frac{0.125}{y^{-15}w^6}$ oe			M1	for two of fourth rooting or reciprocating or cubing
		$\frac{y^{15}}{8w^6}$		A1	allow $\frac{y^{15}}{8w^6}$ or $\frac{y^{15}w^{-6}}{8}$ or $0.125y^{15}w^{-6}$ or $\frac{1}{8}y^{15}w^{-6}$ or $\frac{w^{-6}}{8y^{-15}}$ or $\frac{1}{8y^{-15}w^6}$
	ALTERNATIVE				
			3	M2	for 2 correct terms (M1 for 1 correct term)
		$\frac{y^{15}}{8w^6}$		A1	allow $\frac{y^{15}}{8w^6}$ or $\frac{y^{15}w^{-6}}{8}$ or $0.125y^{15}w^{-6}$ or $\frac{1}{8}y^{15}w^{-6}$ or $\frac{w^{-6}}{8y^{-15}}$ or $\frac{1}{8y^{-15}w^6}$
					Total 6 marks

19 (a)		2	1	B1	
(b)		$8a^3$	2	B2	for $8a^3$ If not B2 then B1 for $8a^k$ where $k \neq 3$ or ka^3 where $k \neq 8$

20 (a)		$\frac{9}{10}$	1	B1 oe	
(b)		-6	1	B1	
					Total 2 marks

21 (a)		1	1	B1	

22	**For one of:** $10^{4n} = (5\times 2)^{4n}$ **or** $5^{4n}\times 2^{4n}$ **or** oe $20^2 = (5\times 2^2)^2$ **or** $5^2\times 2^4$ **or** $5^2\times 2^2\times 2^2$ **or** cancelling 5^2 on numerator with 20^2 to get 16 or 2^4		5	M1	for writing 10^{4n} correctly as a product of 5 and 2 to the power $4n$ oe **or** writing 20^2 correctly as a product of 5 and 2^2 to the power 2 oe **or** cancelling 5^2 on numerator with 20^2 to get 16 or 2^4
	for getting numerator to the stage (this scores M1M1) $2^{4n}\times 2^{3n^2-15n}\times 5^2$ oe eg $2^{3n^2-11n}\times 5^{-4n+4n+2}$ oe **or for two of** $10^{4n} = (5\times 2)^{4n}$ **or** $5^{4n}\times 2^{4n}$ **or** oe $20^2 = (5\times 2^2)^2$ **or** $5^2\times 2^4$ **or** $5^2\times 2^2\times 2^2$ **or** cancelling 5^2 on numerator with 20^2 to get 16 or 2^4 or getting the numerator to the stage			M1	
	$\frac{2^{4n}\times 2^{3n^2}\times 2^{-15n}}{2^4}$ [= 1 **or** 2^0] *or* $2^{4n}\times 2^{3n^2}\times 2^{-15n} = 2^4$ oe			M1	For writing the equation in powers of 2 only
	$3n^2 - 11n - 4$ [= 0]			A1	Correct quadratic equation dep on M1
	working required	$-\frac{1}{3}$, 4		A1	Both answers required dep on M1
					Total 5 marks

23	(a)		m^7	1	B1	
	(b)		8	1	B1	Allow k^8
	(c)		$9x^{12}y^{16}$	2	B2	B1 for a product in the form ax^py^q where 2 from a , p or q are correct eg $3x^{12}y^{16}$ (Allow $9x^{12}$ or $9y^{16}$ or $x^{12}y^{16}$ so as long as not added to any other terms)
						Total 4 marks

24	(a)		1	1	B1 cao	
	(b)		-6	1	B1 Allow 3^{-6}	
						Total 2 marks

25	(a)		$8c^{12}d^{21}$	2	B2	(B1 for 2 correct terms as part of a product)
	(b)		5	1	B1	
	(c)		$4a^2b(4b^2 + 5a)$	2	B2	B1 for any correct partial factorisation with at least 2 factors, **or** the correct common factor with no more than 1 error inside the bracket
	(d)(i)	$(x \pm 11)(x \pm 2)$		2	M1	for $(x \pm 11)(x \pm 2)$ **or** for $(x + a)(x + b)$ with $ab = -22$ or $a + b = 9$
		Correct answer scores full marks (unless from obvious incorrect working)	$(x + 11)(x - 2)$		A1	for correct factors
	(ii)		$-11, 2$	1	B1ft	ft dep on factorising in the form $(x + p)(x + q)$
						Total 8 marks